ROYAL ASTRONOMICAL SOCIETY.

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Arthur Kett Barclay, Esq., V.P., in the Chair.

J. S. Ancona, Southampton Street, Bloomsbury; and James Cockle, Esq., of the Middle Temple,

were balloted for and duly elected Fellows of the Society.

Vol. xxii. of the *Memoirs* has recently been published. It contains three plates of engravings, besides a series of wood-cut illustrations, accompanying one of the papers. The price of the volume is 7*s.* to Fellows and 14*s.* to the public. Vol. xiii. of the *Monthly Notices*, which contains shorter communications, abstracts of papers, lectures, &c., is *given* to purchasers of the 4to. volume. The two publications are supplementary to each other, and are to be considered as part of the same series. They contain scarcely anything in common, except the Annual Report; and between them include a complete account of the proceedings of the Society during the year.

Extract of a Letter from M. Hansen to the Astronomer Royal.

"In respect to the *Astronomische Nachrichten*, I can communicate to you that the Royal Danish Government has provisionally voted the grant for the completion of the volume now in the press, and that I shall provisionally continue the editing of the work. I, therefore, request you, as well as all other English astronomers, to have the goodness to send to me all communications for this journal."

Observations of Comet III., 1853.

The following observations of a comet (apparently Comet III, 1853) seen at Auckland, New Zealand, on board H.M.S. Calliope, were made by Mr. G. P. Heath, acting under directions of Capt. Sir J. E. Hare, Bart., F.R.S., and were transmitted to Capt. King, of Paramatta, N.S.W., who communicated them to the Society through the Rev. Geo. Fisher.

"The comet was first seen about 4 A.M. upon the 13th September, very distinctly. The morning of the 14th was cloudy. On the 15th, at $5^h\ 11^m$ A.M., between two squalls it was again seen. It was colourless. The length of the tail was $4°\ 45'$, gradually widening from the head; the extreme width about $\frac{1}{2}°$: produced, it would pass about 10° to the south-eastward of *Canopus*. Its posi-

Mean of the following two observations :—

HAMBURG.

	Hamburg M.T.	R.A.	Decl. N.
	h m s	° ′ ″	° ′ ″
March 4	10 21 41	180 55 52·9	7 28 46·2

BONN.

		R.A.	Decl. N.
		° ′ ″	° ′ ″
March 4	Meridian	180 54 29·0	7 29 48·0

DURHAM.

	Green. M.T.	R.A.	Decl. N.
	h m s	° ′ ″	° ′ ″
March 11	13 7 33	179 40 24·6	8 35 10·7

Professor Chevallier has sent to the Society, for distribution, several printed copies of an ephemeris of the planet calculated from the foregoing elements, and extending from March 15 to April 16.

A NEW COMET.

A new comet has been discovered, which became generally visible to the naked eye on the 29th of March. Mr. Carrington writes word that it was first seen by him, and unexpectedly, at about $7^h\ 38^m$ G.M.T., on the 29th, and makes the same remark that others have done respecting its general similarity to the one of August last. He obtained two pretty good comparisons with the star B.A.C. 348 before the comet set, and hastened to London on the morning of the 30th to circulate them, when he found that the comet had been already seen elsewhere. He too observed it on the 29th, 30th, 31st of March, and on the 1st and 2d of April; but the observations will not be fully reduced in time for the present *Notice*. From the following three positions, approximately made out for the purpose, he has computed the subjoined parabolic elements :—

1854.		R.A.	N.P.D.
	h m s	h m s	° ′ ″
March 29	8 0 13·7	1 6 22·48	70 12 13·0
30	8 7 22·7	22 0·40	22 12·0
31	7 32 3·4	1 36 56·33	70 44 8·6

T	1854, March 24^d·13742, Green. M.T.	
	° ′ ″	
π	211 43 27	M. Eq. 1854·0
Ω	313 44 20	
I	81 39 6	
Log q	= 9·443310	Retrograde.

Notice of the Comet. By E. J. Lowe, Esq., at Highfield House Observatory, near Nottingham.

"I discovered a large and brilliant comet this evening (March 29th) at $7^h\ 50^m$, which was situated a few degrees above the N.W. by W. horizon. Clouds in the neighbourhood prevented me marking its position as accurately as I could have wished, and the want of an equatoreally-mounted telescope renders the position a very rough estimate. It appears to be situated on the border of *Pisces*, not far from η *Andromedæ*. The nucleus was equal to a star of the

2d magnitude, and the tail (which extended in the direction of *Polaris*) was about 4° in length.

Elements of the comet from three observations at Mr. Bishop's Observatory, on March 29, 30, and 31. By J. R. Hind, Esq.

Per. Pass. 1854, March 24·33842, G.M.T.

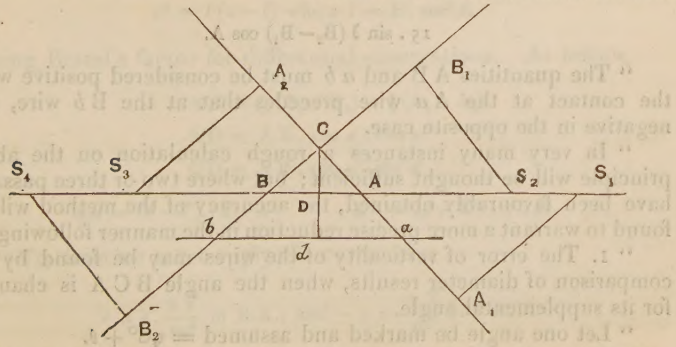
π	207 34 8	T.E., March 30
Ω	310 22 32	
i	79 27 14	
log q	9·445695	

Retrograde.

On a Method of Observing the Positions of Spots on the Sun; with an Example of its Application. By R. C. Carrington, Esq.

"The following method occurred to me in the month of October of last year, and has been made use of at Redhill on every subsequent occasion on which the sun has been visible. The advantages for which I would recommend it are, that it requires no previous accurate adjustment of a wire frame; that direct vision of the sun is unnecessary; that the contacts by which the position of the centre is determined are thrown to the beginning and end of the observation, so that an uninterrupted space of about three minutes is given for observing the contacts of the spots; and that the whole observation takes so little time that records may be procured on days of broken weather, when it would often be impossible otherwise to get an observation at all.

"In the focus of the equatoreal are placed two wires at right angles, turned *approximately only* into the position of 45° inclination to a parallel of declination, and the image of the sun's disk and the cross-wires is projected on a screen, placed at such a distance that the projection of the disk may measure from 12 to 14 inches. The most effective screen I have yet tried consists of a plate of ground glass, covered with whitewash, tinted a pale straw colour, with dark cloth or dead-black cartridge paper placed behind. The sun is, of course, seen to run along the screen from



right to left, the true north limb being the upper limb on the screen

" In the figure, the sun's centre is supposed to run along the line $S_1 S_4$, passing south of the intersection point C; and $a\,b$ to be in like manner a portion of the path of a spot. When the centre has arrived at a point S_1, such that the length of the perpendicular from S_1 on either of the wires, as $S_1 A_1$, is equal to the radius of the disk, a contact of the disk with the wire will take place, the instant of which is to be observed. There will be four such contacts in all, the times of which are conveniently denoted by the letters A_1, B_1, A_2, B_2.

" The line C D d is supposed to be dropped perpendicular on the paths of the centre and of the spots.

" In the first instance, for simplicity, neglecting the effects of refraction, of hourly motion, and of error of verticality of the wires, we shall have by the geometry of the case,

$$\frac{BC}{2 \cdot AB} = \frac{S_1 A_1}{S_1 S_3} = \frac{r}{15 \cdot \sin \delta\,(A_2 - A_1)}$$

$$\frac{AC}{2 \cdot AB} = \frac{S_2 B_1}{S_2 S_4} = \frac{r}{.15 \sin \delta (B_2 - B_1)}$$

whence
$$\frac{BC}{AC} \text{ or } \tan BAC = \frac{B_2 - B_1}{A_2 - A_1}.$$

" The centre passes A at $\frac{1}{2}(A_1 + A_2)$, and B at $\frac{1}{2}(B_1 + B_2)$; and, therefore, from A to B in the time $\frac{1}{2}(B_1 + B_2) - \frac{1}{2}(A_1 + A_2)$.

$$AD = AB \cdot \cos A \cdot \cos A$$
$$CD = AB \cdot \cos A \cdot \sin A$$

" Let T stand for $\frac{1}{2}(A_1 + A_2) + AD$, and D for C D; t and d being similar quantities for a spot. Then the difference of R.A. in arc, and of N.P.D. for a spot, as compared with the sun's centre, will be

$$15 \cdot \sin \delta \cdot (t - T) \text{ and } 15 \sin \delta\,(d - D),$$

and the diameter of the sun will be

$$15 \cdot \sin \delta\,(B_2 - B_1) \cos A.$$

" The quantities A B and $a\,b$ must be considered positive when the contact at the A a wire precedes that at the B b wire, and negative in the opposite case.

" In very many instances a rough calculation on the above principle will be thought sufficient; but where two or three passages have been favourably obtained, the accuracy of the method will be found to warrant a more precise reduction in the manner following:—

" 1. The error of verticality of the wires may be found by the comparison of diameter results, when the angle B C A is changed for its supplemental angle.

" Let one angle be marked and assumed $= 90° + \theta$.

" Supposing the wires to be adjusted not much out of the

described position, there will be no difficulty in seeing that the expression for the diameter will be

$$2r = 15 \cdot \sin \delta \cdot (B_2 - B_1) \cos A \cdot (1 - \tfrac{1}{2} \sin \theta).$$

" If the unmarked angle be now substituted, we shall have

$$2r = 15 \cdot \sin \delta \cdot (B'_2 - B'_1) \cos A' \cdot (1 + \tfrac{1}{2} \sin \theta);$$

from which θ may be found, if desired. The quantity actually required is the factor $(1 - \frac{1}{2} \sin \theta)$, which we will denote by the letter G, and by which all our results must be multiplied.

" 2. The effect of refraction may be taken into account with sufficient accuracy by assuming every point on the disk refracted upwards in a line parallel to the vertical circle through the centre, and that the difference of refraction of any two points in the same such line is proportional to their distance. In this case, the disk will be strictly elliptic; and, in place of the radius in the previous expressions, we must substitute the expression for the perpendicular from the centre of an ellipse on its tangent.

" 3. The effect of the hourly motion is disposed of by the consideration that, as the results are independent of the angle at which the sun's path cuts the wires, the motion in R.A. will affect the scale of the results only, and the motion in N.P.D. the angles only. We shall, therefore, include their effects by multiplying all our results by the well-known factor $\frac{3600}{3600 + I}$; and, by a slight transformation of co-ordinates for I', the motion in N.P.D.

" The accurate formulæ will, accordingly, stand thus :—

$$F = 15 \cdot \sin \delta \cdot \frac{3600}{3600 + I} \qquad G = (1 - \tfrac{1}{2} \sin \theta)$$

$$\tan \alpha = \frac{B_2 - B_1}{A_2 - A_1} \qquad \tan \alpha' = \tan \alpha \cdot \sqrt{\frac{1 - e^2 \cdot \cos^2 (\alpha + s)}{1 - e^2 \cdot \sin^2 (\alpha + s)}}$$

in which s is the angle contained by the great circles drawn from the sun's centre to the pole and the zenith, and is to be considered + for east hour-angles, and — for west; and in which e is the eccentricity of the disk.

$$e^2 = l (2 - l) \text{ where } l = k \cdot \sec^2 z,$$

k being Bessel's factor for differential observations. As before,

$$AB = \tfrac{1}{2} (B_1 + B_2) - \tfrac{1}{2} (A_1 + A_2)$$
$$AD = AB \cdot \cos \alpha' \cdot \cos \alpha'$$
$$CD = AB \cdot \cos \alpha' \cdot \sin \alpha'$$

$$\Delta \alpha = (t - T) \cdot F \cdot G \qquad \Delta \delta = (d - D) \cdot F \cdot G.$$

" To these we must apply the corrections

$$+ \Delta \delta \cdot \frac{2 I'}{10^5} \text{ in R.A., and } - \Delta \alpha \cdot \frac{2 I'}{10^5} \text{ in N.P.D.}$$

for the hourly motion I′, which is to be considered +, when the sun's N.P.D. is increasing.

" Lastly, the corrections,

$$k \sec^2 z \,.\, \sin s \,.\, (\Delta\alpha \,.\, \sin s + \Delta\delta \,.\, \cos s) \quad \text{in R.A.}$$

and $$k \sin^2 z \,.\, \cos s \,.\, (\Delta\alpha \,.\, \sin s + \Delta\delta \,.\, \cos s) \quad \text{in N.P.D.}$$

for difference of refraction.

" The sun's diameter will be

$$(B_2 - B_1) \,.\, F \,.\, G \,.\, \cos\alpha' \,.\, \frac{1+k}{\sqrt{1-e^2 \sin^2(\alpha+s)}}$$

" As an example of the application of the formulæ, I have selected the observations of Nov. 25, 1853, the spots on that day being only two in number, and so situated as to illustrate the signs of the different quantities.

" The spots are denoted P and Q, and the times of passing the A a wire by P_a and Q_a, and of the B b wire by P_b and Q_b.

	Bar. 29in·85		Therm. 40°·3	Means.
	h m s	h m s	h m s	h m s
B_1	17 25 43·0	17 29 30·9	17 34 14·1	17 29 49·33
A_1	25 50·0	29 37·0	34 20·0	29 55·67
P_a	27 27·8	31 15·1	35 58·0	31 33·63
P_b	27 44·1	31 32·0	36 14·9	31 50·33
Q_b	27 45·4	31 33·4	36 16·2	31 51·67
Q_a	28 3·1	31 50·8	36 34·0	32 9·30
B_2	28 59·3	32 47·0	37 30·0	33 5·43
A_2	17 29 7·0	17 32 54·1	17 37 37·3	17 33 12·80

" The steps of the reduction will be as follow:—

	h m s
$\frac{1}{2}(B_1+B_2)$ =	17 31 27·38
$\frac{1}{2}(A_1+A_2)$ =	17 31 34·24
Mean = sun's transit =	17 31 30·8
Clock slow	14·4
	17 31 45·2
Add for longitude	41·3
	17 32 26·5

whence Greenwich mean time of observation, 1853, Nov. 25, $1^h\ 14^m\ 52^s{\cdot}5$. By the *Nautical Almanac*,

$\alpha = 16^h\,4^m\,50^s$ $\quad I = +10^s{\cdot}65$ $\quad \delta = 110°\,49'{\cdot}3$ $\quad I' = +28''{\cdot}7$

whence, $z = 74°\,33'$ $\quad h = 1^h\,27^m$ west $\quad s = -13°\,56'$

" With zenith distance, barometer, and thermometer as arguments,—

$\text{Log } k = 6{\cdot}4349$

In our case $\text{Log } G = 0{\cdot}00010$

whence, $\text{Log } F.G = 1{\cdot}14557$

$B_2 - B_1 = 196'{\cdot}10$

$A_2 - A_1 = 197{\cdot}13$ whence $\log \tan \alpha = 9{\cdot}99772$ $\alpha = 44^\circ 51'$

$s = -13\ 56$

$\alpha + s = 30\ 55$

$\text{Log } e^2 = 7{\cdot}8839$

whence, $\text{Log}(1 - e^2 \cos^2 \overline{\alpha + s}) = 9{\cdot}99755$

$\text{Log}(1 - e^2 \sin^2 \overline{\alpha + s}) = 9{\cdot}99912$

Half the diff. $= 9{\cdot}99922$, which added to log tan α gives log tan $\alpha' = 9{\cdot}99694$; whence $\alpha' = 44^\circ\ 47'{\cdot}9$.

$AB = -6^s{\cdot}860$			Semidiameter.
$\text{Log } AB = -0{\cdot}83632$			$\frac{1}{2}(B_2 - B_1) = 98{\cdot}050$
$\text{Log cos } \alpha' = 9{\cdot}85101$			Log $= 1{\cdot}99145$
$-0{\cdot}68733$	$-0{\cdot}68733$		L cos $\alpha' = 9{\cdot}85101$
L cos α' $9{\cdot}85101$	L sin $9{\cdot}84795$		Log F.G $= 1{\cdot}14557$
$-0{\cdot}53834$	$-0{\cdot}53528$		Log $(1+k) = 0{\cdot}00012$
$-3{\cdot}454$			$2{\cdot}98815$
$17\ 31\ 34{\cdot}235$			Log $\surd$..... $= 9{\cdot}99956$
$T = 17\ 31\ 30{\cdot}781$	$D = -3{\cdot}430$		$2{\cdot}98859$
			$\frac{1}{2}$ diam. $974''{\cdot}1$
$\frac{2I'}{10^5} = +{\cdot}0006$			By *Naut. Alm.* 975 ·0

Spot P.		Spot Q.	
$ab = +16^s{\cdot}700$		$ab = -17^s{\cdot}630$	
$\text{Log } ab = +1{\cdot}22272$		$\text{Log } ab = -1{\cdot}24625$	
L cos α' $9{\cdot}85101$		L cos $\alpha' = 9{\cdot}85101$	
$+1{\cdot}07373$	$+1{\cdot}07373$	$-1{\cdot}09726$	$-1{\cdot}09726$
L cos α' $9{\cdot}85101$	L sin $9{\cdot}84795$	L cos α' $9{\cdot}85101$	L sin $9{\cdot}84795$
$+0{\cdot}92474$	$+0{\cdot}92168$	$-0{\cdot}94827$	$-0{\cdot}94521$
$+8{\cdot}409$		$-8{\cdot}877$	
$P_a = 17\ 31\ 33{\cdot}630$		$Q_a = 17\ 32\ 9{\cdot}300$	
$t = 31\ 42{\cdot}039$	$d = +8{\cdot}350$	$t = 32\ 0{\cdot}423$	$d = -8{\cdot}815$
$T = 31\ 30{\cdot}781$	$D = -3{\cdot}430$	$T = 31\ 30{\cdot}781$	$D = -3{\cdot}430$
$t - T = +11{\cdot}258$	$d - D = +11{\cdot}780$	$t - T = +29{\cdot}642$	$d - D = -5{\cdot}385$
$\text{Log F.G} = 1{\cdot}14557$	and $s = -13^\circ\ 56'$	$\text{Log F.G} = 1{\cdot}14557$	and $s = -13^\circ\ 56'$
$\therefore \Delta\alpha . \sin s + \Delta\delta . \cos s = +122''$ whence		$\therefore \Delta\alpha . \sin s + \Delta\delta . \cos s = -173''$ whence	
$\Delta\alpha = +157''{\cdot}4$	$\Delta\delta = +164''{\cdot}7$	$\Delta\alpha = +414''{\cdot}5$	$\Delta\delta = -75''{\cdot}3$
Corr. for I' $+ 0{\cdot}1$	$- 0{\cdot}1$	Corr. for I' $- 0{\cdot}0$	$- 0{\cdot}2$
Diff. refr. $- 0{\cdot}1$	$+ 0{\cdot}5$	Refr. $+ 0{\cdot}2$	$- 0{\cdot}6$
$+157{\cdot}4$	$+165{\cdot}1$	$+414{\cdot}7$	$-76{\cdot}1$

"The corrections applied to $\Delta\alpha$ and $\Delta\delta$ may appear small, but in cases where the spots lie further from the centre they are more necessary. It will further illustrate the method to exhibit the

results of each passage separately, reduced without correction for refraction on the quantity I′.

	½ Diam.	Spot P.		Spot Q.	
	″	″	″	″	″
1st set	972·1	Δα +156·1	Δδ +165·3	Δα +411·2	Δδ −72·3
2d —	971·9	158·8	164·3	417·0	75·5
3d —	971·9	156·4	164·3	415·4	78·3

"I am not aware that the above sets are better or worse than usual, or that there exists any reason why they may not be taken as a fair sample.

"I think the time required for the whole observation will speak for itself, and I hope that the degree of accuracy attained will induce some other observer to think the method worthy a trial.

"As a last word, I would just point out that there is one objection to the use of cross bars instead of cross wires, which some might otherwise prefer. It not unfrequently happens that a group of spots of some extent lies nearly on the parallel of the sun's centre. In such a case the large space taken up by the crossing of the bars will prevent all the contacts being taken at the same passage, unless the centre be thrown to an objectionable distance from the point of intersection."

On some peculiar Features in the Structure of Lunar Volcanic Craters. By James Nasmyth, Esq.

In pursuing my investigations of the features of the lunar surface, aided by my very convenient 20-inch aperture reflecting telescope, I have been much interested in observing the details of what have hitherto been termed "terraces," namely, certain concentric ridges around the interior walls of the lunar volcanic craters; and as their peculiar features appear to me to throw some additional light on the nature of the action which had caused the formation of those remarkable "ring mountains," and which I take to be in reality the craters of extinct volcanoes, a few remarks on the subject may, perhaps, prove acceptable.

On a careful scrutiny of these concentric ridges above alluded to, I find that they are by no means continuous or regular in respect to height or position, but, on the contrary, are indented and broken, and that in many cases they form but a small segment of the interior wall of the crater; while, in other cases, portions of these "terraces" have slipped down, and that the flat bottom or plateau of the crater at the spot is covered with the *débris* of portions of the interior wall,—in short, that these features are the result of vast "*landslips*," which, when occurring to any great segment of the inner wall of the crater, yield the "terrace-like" appearance, while in a more limited extent they leave a notch or recess in the bank or cliff, and the *débris* seen at the base are the fragments of the landslip, many portions of which may be traced scattered about and projected inwards towards the centre of the

plateau. When these features are carefully examined with this "landslip" idea present in the mind, the evidences of such being the true cause and nature of their appearance become irresistible; inasmuch as that any one who has seen "landslips," and the fallen-in interior walls of volcanic craters, will be struck with the similarity of the aspect of the features in question.

With respect to the cause and the nature of the action which appears to me to have occasioned the features in question, I consider that the most probable explanation is, that during the most active state of those volcanic craters the matter ejected from the volcano accumulated, and was piled up to such a height on the summit of the great circular wall or crater, as by its crushing-down action, aided by the undermining and softening action of the intensely hot lake of molten lava (then occupying the bottom of the crater), the vast superincumbent mass forming the wall of the crater had, from time to time, and to a greater or less segmental extent, crushed and slid down, and so settled in a more permanent position: when occurring to a great segment, resulting in the "terrace-like" appearance; and when in a more limited extent yielding all the well-known features of a "*landslip*."

It occurs to me, that if any one (having suitable telescopic means) will carefully examine the details of these features, they will not fail to regard these remarks as worthy of consideration, as yielding what appears to me a rational explanation of their nature and origin.

I may state that I consider the era of the active condition of the lunar volcanoes to have gone by ages ago.

Extract of a Letter from M. Otto Struve to the Astronomer Royal, dated January 17, 1854.*

"In the last months I have been so much engaged with other things that I could not find leisure to calculate my observations on the parallax of 61 *Cygni*. But Prof. Woldstedt being here on a visit in the month of September, has made a preliminary calculation, which gives

By the distances, the parallax $= +0''.542 \pm 0''.033$
By the positions, $= +0''.504 \pm 0''.045$

or, in the mean, a parallax greater by nearly one-third than Bessel's value. The proper motion deduced from my observations agrees within one or two hundredths of a second with that deduced from meridian observations. It was a very curious fact that, when first Woldstedt, by application of proper motion, had reduced the measures to one epoch, I was able to point out, by a single view, the epochs of the different maxima and minima, so exactly that the afterward calculated real epochs did in no case differ from my estimate by more than ten days. I do not regard Prof. Woldstedt's

* For a further extract from the same letter, see p. 167.

calculation as definitive, but the ultimate corrections to be applied to the values he has found, I suppose, will not exceed 0″·02. How to explain the difference between Bessel's determination and mine is more than I can say at present. Perhaps it has originated merely from an accumulation of accidental error in opposite directions for the two series; but, more probably, it might be attributed in part to the action of the same uncommon causes, which evidently have disturbed in much higher degrees Wichmann's observations, and about which Doellen's researches contain very curious indications.

"In speaking here of constant or systematical errors, to which heliometrical measures are subject, it would not be right to avoid mentioning that likewise my own measures, made with the wire-micrometer, are not free from similar errors. On the contrary, a long series of experiments, made on artificial double stars, indicate very important corrections to be applied to all my measures of *close* double stars. From a great number of observations I have deduced the following empirical formula for the correction of positions, measured by me on double stars, 0″·8 to 6″ of distance :—

$$\text{Corr.} = + \frac{4^{\circ}\cdot 23}{\alpha} + 3^{\circ}\cdot 24 \sin (2\,\varphi - 29^{\circ}\,11') + 1^{\circ}\cdot 51 \sin (4\,\varphi - 31^{\circ}\,29')$$

"In this formula α is the distance expressed in seconds and φ the angle between the true direction of the double star and the vertical circle passing through the star at the time of observation.

"At about 6″ of distance the method of observation changes. It must be attributed to this circumstance, that for greater distances the coefficients of the empirical formulæ diminish rapidly, so that, at a distance of 12″, the systematical errors disappear altogether, or are incomparably smaller than the little accidental errors of observation. Hence it follows that my determination of parallaxes is quite free from these systematical errors.

"The constant errors of the measured distances are, generally speaking, less important, as it might be seen from the following list :—

True Dist.	Corr. of Meas. Dist.	True Dist.	Corr. of Meas. Dist.
″	″	″	″
0·99	+0·029	7·88	+0·094
1·94	0·079	11·60	+0·032
3·88	+0·136		

"I think the origin of all these errors in the measured positions is quite physiological, and it is highly probable that all practical observers will be subject to similar systematic errors. It requires no demonstration, that similar corrections will change *very considerably* all hitherto deduced elements of the orbits of double stars, especially as these are commonly deduced from the observed positions. Therefore, in future times, no other observations ought to be employed for that purpose, but those for which the personal corrections are well ascertained by direct experiments or by comparison with corrected observations.

"One other consequence which might be deduced from the existence of such errors is, that we must be very sceptical with regard to parallaxes deduced in the way in which it had been done by Capt. Jacob for *α Herculis;* most probably the parallax he has found in this case is nothing more than a strong indication that the positions observed by him are subject to similar systematic errors as mine: for in itself it is highly improbable that *α Herculis* and its companion should have different parallaxes. My researches on the constant errors of my observations are not yet closed, for there are yet many questions undecided. I shall continue them most probably throughout the whole ensuing summer, and only when they are finished I shall proceed to the publication of my fifteen years' observations of double stars."

On Two New Theorems in Lunar Astronomy. By Professor Challis.

(*Extract of a Letter from Professor Challis to the Editor.*)

"I have succeeded in demonstrating, on the principle of gravitation, two new theorems relating to the moon's orbit.

"Theorem I. All small quantities of the second order being taken into account, the relation between the radius vector and the time in the moon's orbit is the same as that in an orbit described by a body acted upon by a force tending to a fixed centre.

"If μ be the sum of the attractions of the earth and moon, and m' the attraction of the sun at the unit of distance, and if r be the moon's radius vector, and a' the sun's mean distance from the earth, the central force is $\frac{\mu}{r^2} - \frac{m' r}{2 a'^3}$. The theorem is true inclusive of the moon's motion in latitude.

"The integration by which the relation between the radius vector and the true longitude on the orbit is obtained, gives directly the mean motion of the apse to the first approximation.

The same integration involves the following consequence:—

"Theorem II. The excentricity of the moon's orbit is a function of the ratio of the moon's periodic time to the earth's periodic time, and, to the first approximation, is equal to that ratio divided by the square root of 2.

"This theorem applies to the *constant* part of the excentricity, and depends entirely on the circumstance that the apse has a mean motion.

"The proofs of these theorems are contained in a communication to the Cambridge Philosophical Society.

"*Cambridge Observatory, March* 9, 1854."

An Account of the Hartwell Rectory Observatory.
By the Rev. C. Lowndes.*

"It might be thought that an Observatory on the Rectory grounds at Hartwell would be quite unnecessary, as Dr. Lee has

* A model of this observatory has been sent to the apartments of the Society, which Dr. Lee explained at the last Meeting.

such an excellent one so near, to which, out of pure love of and to advance the science, he has given me, and indeed all who take an interest in astronomy, free access. But, as in the spring of 1849, I had commenced taking meteorological observations for the British Meteorological Society, of which I have been a member from its formation, I was very anxious to have an observatory of my own, and decided upon building a very *small* one. My friend and neighbour, the Rev. J. B. Reade, mentioned my intention to Dr. Lee, when he very generously and kindly said, if I would build a larger one, he would give me all the materials. Such an offer I was only too glad to accept, and, accordingly, I set about the work of building a transit-room, intending, when circumstances would allow, to add an equatoreal-room. A committee was formed at Dr. Lee's suggestion, consisting of himself, the Rev. J. B. Reade, and T. Dell, Esq., to fix upon a site, and to superintend the work.

"The site is the best, under the circumstances, which could be chosen, and commands the passage of *Fomalhaut* to the south. As no distant object can be seen, and there are no meridian marks, I am compelled to adjust the collimation by the passage of *Polaris*, and thus obtain the error.

"*The transit-room* is substantially built of *brick*, upon a *solid bed of concrete*, and is 10 feet square in the clear, and 8 feet 9 inches high, the top being covered with lead and the two shutters with copper. The floor is supported by joists, forming square frames round the transit and clock-piers, so that no tremor can be communicated by the planks; and the clock and two transit-piers are also placed upon *solid beds of concrete*, independent of the walls of the building. The two piers supporting the transit instrument are of *Caen stone*, 4 feet 11 inches above the floor.

"The transit instrument was made by Mr. T. Slater, optician, No. 4 Somers Place West, New North Road, London, and is supported upon brass Y's by two cones, which form an axis of 2 feet 5 inches in length, the pivots which rest in the Y's being made of bell-metal $1\frac{3}{4}$ inches in diameter. Two adjustments are attached to the Y's, the one on the west pier for making the axis horizontal, the other on the east pier for adjusting the telescope in azimuth. The telescope is 5 feet 7 inches in length, having an object-glass, whose aperture is $4\frac{3}{4}$ inches in diameter. There are five fine vertical wires and six thicker ones, for taking faint objects, placed in the principal focus, the intervals by *Polaris* of the five fine wires being $10^m 44^s$. The *setting circles* are fixed at the eye-end of the telescope; they are 6 inches in diameter, and are divided on silver. There is also a dew-cap fixed at the object-end, made of zinc, densely blackened within.

"The *level* used for adjusting the horizontal position of the axis of the transit instrument was also made by Mr. T. Slater; the value of each division is one second in space.

"*The clock*, which is placed in the south-west corner of the building, was made expressly for me by Mr. Dent; and a very excellent one it has proved. It has a compensating pendulum, and

a particularly good beat, and keeps an equitable losing rate; the variation on its rate being (invariably) less than one-hundredth of a second. It has a tendency to gain this quantity in the cold weather, and to lose it in the warm weather."

The foregoing description was accompanied by an account of the meteorological department of the Observatory and a detailed statement of the expenses connected with the undertaking. The following is the recapitulation on the latter head:—

	£	s.	d.
Cost of the building	55	0	9
Cost of astronomical instruments	138	10	0
Cost of meteorological instruments	17	2	0
Total	210	12	9

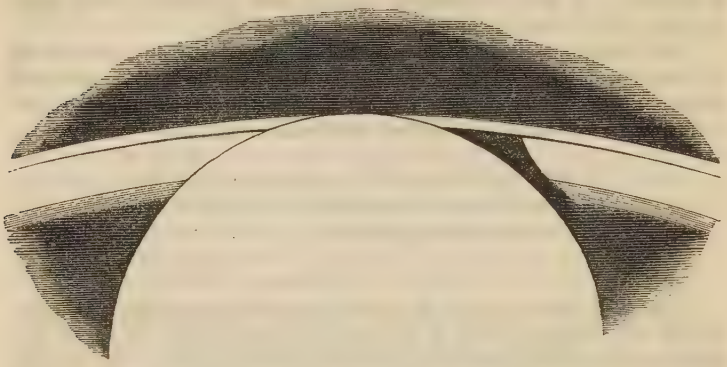
The paper also contained a few transits taken by Mr. Lowndes, at his Observatory; and a few similar observations made at the Observatory of Hartwell House by Dr. Lee's Assistant. The results for the several wires are very accordant in both cases.

Remarkable Appearance of the Shadow of Saturn projected on the Ring. By J. Hippisley, Esq.

"I observed *Saturn* near, and on the meridian, with a Newtonian equatoreal of $9\frac{1}{4}$-inch aperture, powers 360 and 462. The atmosphere afforded conditions of very unusual definition. I perceived distinctly a faint line or belt on the outer ring, at about three-fifths of its breadth from the inner edge. This line did not at all give the impression of a *division;* but as compared with the tint of the main separation of the rings, was, though of sensible breadth, of a much paler and fainter shade. Having on a previous occasion of similar, but equally rare, atmospheric tranquillity, had the advantage of viewing *Saturn* with Mr. Lassell's 20-foot telescope, and recalling some other circumstances of even superior definition with which the planet, as to its other features, was then seen, I feel assured that the outer ring was not at that time marked by any similar belt or line; and that those markings are therefore of a variable character.

"But the most remarkable feature was the shape and position of the shadow of the ball. This was conspicuously curvilinear, with the convexity towards the ball; and of such curvature that the curve produced ought to have passed over a considerable portion of the outer ring, if that ring had been in the same plane with the inner. It did not, however, visibly touch the outer ring at all; which retained its brightness unshaded up to the point at which it was occulted by the vertex of the ball; affording, it might seem, evidence that the plane of the outer ring was sensibly raised, at that side, above the edge of the inner: moreover, the impression derived from the shape of the shadow was that the surface of the inner ring was convex, and perceptibly thicker at the middle than at either of its edges.

" I subjoin a sketch of that portion of the planet necessary to exhibit the position of the shadow; and perhaps it may be de-



sirable to add, with reference to the value of the observation, as illustrative of the quality of the vision afforded by the condition of the atmosphere, and the excellence of a speculum lately refigured for me by Mr. Lassell, that the small star of ν *Andromedæ*, also near the meridian, was readily *divided* with the power 462, the division being seen not by occasional and instantaneous glimpses, but steadily and repeatedly for three or four seconds at a time, with such distinctness that an eye used to such objects could scarcely have overlooked the duplicity. The transparency also of *Saturn's* faint ring was also satisfactorily visible, especially at the preceding limb of the ball, where it was more manifest than at the other side."

Observations of Amphitrite and Bellona made at the Observatory of Cambridge. By Professor Challis.

AMPHITRITE.

CAMBRIDGE.

1854.	Green. M.T. h m s	R.A. h m s	Par. Corr. × Δ. s	N.P.D. ° ′ ″	Par. Corr. × Δ. ″	No. of Comps.	Star.
March 6	11 48 21·8	13 15 2·08	−0·215	100 3 56·0	−7·37	13	*a*
11	11 42 48·2	13 11 54·65	−0·193	99 58 56·6	−7·41	6	*a′*
13	10 53 47·5	13 10 32·19	−0·242	99 56 12·7	−7·31	10	*b*
16	13 30 36·1	13 8 11·68		99 50 28·9	−7·55	Meridian.	

Assumed Apparent Places of the Stars.

	Apparent R.A. h m s	Apparent N.P.D. ° ′ ″	Catalogue.
a	13 16 16·79	100 6 26·0	Bessel xiii. 256
a′	13 16 16·88	100 6 26·6	—
b	13 9 49·87	99 46 34·0	Bessel xiii. 155

BELLONA.

CAMBRIDGE.

1854.	Green. M.T. h m s	R.A. h m s	Par. Corr. × Δ. s	N.P.D. ° ′ ″	Par. Corr. × Δ. ″	No. of Comps.	Star
March 10	10 41 4·4	11 59 29·80	−0·183	81 34 50·0	−6·02	8	*c*
11	10 13 32·2	11 58 46·88	−0·213	81 25 44·9	−6·05	9	*c′*
13	12 31 37·3	11 57 13·51		81 6 51·8	−5·85	Meridian.	
16	12 17 34·9	11 54 58·49		80 40 11·8	−5·80	—	

Assumed Apparent Places of the Star.

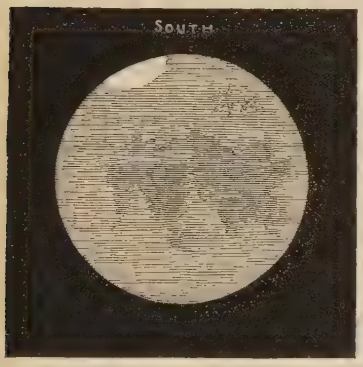
	Apparent R.A. h m s	Apparent N.P.D. ° ′ ″	Catalogue.
c	11 56 50·95	81 47 15·3	Bessel xi. 973
c′	11 56 50·96	81 47 15·4	—

The equatoreal observations were taken with the Northumberland telescope.

On the Influence of Climate upon the Telescopic Appearance of a Celestial Body. By James William Grant, Esq.

(*Extract of a Letter to the Editor.*)

"I send you two sketches of *Mars*, made whilst the planet was in opposition. No. 1 was an attempt made in October 1847 to depict it as seen in Calcutta through a 5-foot achromatic belonging to me, the planet being then in opposition; No. 2 I tried my



1

2

hand upon a few days ago, and it shows what I saw through the large telescope.* The atmosphere in India is very different for observation to anything I have seen here. My Indian sketch, you will observe, is actually a little world; and I doubt whether the large glass here would show it equally well, even were the weather favourable, which, I am sorry to say, hitherto it has not been.

* The telescope to which Mr. Grant refers is a refractor of 11 inches aperture and 16 feet focal length, by Mr. Ross, of Featherstone Buildings. It is the instrument which formed such a conspicuous object in the nave of the Crystal Palace during the Great Exhibition of 1851.

There is a very fine 5-foot achromatic, mounted as a finder, to my large instrument; and I tried it on *Mars*, with the same power I used when taking the Calcutta sketch; but it was very poor. I send you these particulars, that you may mention them to those who have to decide upon getting up a large instrument for a finer climate than England, as I think that different climates should be tried before the position is finally fixed upon.

"*Wester Elchies, March* 14, 1854."

Extract of a Letter from Professor Colla to Mr. Hind, dated Dec. 5, 1853.

"I have the satisfaction of informing you that on the morning of the 29th of November, I found the comet of Bruhns after its passage of the perihelion, above the star δ of *Serpentarius*. I employed in searching for it a refractor by Lerebours, of 4 inches aperture, with a magnifying power of 60, but it was only with the greatest difficulty that I succeeded in seizing it; for it is extremely faint, without nucleus, without trace of tail, exhibiting only, even with a magnifying power of 100, a very minute nebulosity of uniform brightness, with a feeble appearance of scintillation by intervals.

"I observed it again about 6 o'clock on the morning of the 30th of November, but even with greater difficulty, for it appeared very close to a bright telescopic star which rendered it almost insensible.

"At $5^h\,45^m$ on the morning of December 3, the sky being very clear, I found the comet again with facility. The nebulosity was more distinct, but there was no trace of nucleus, of tail, or of scintillation, even when employing a magnifying power of 100. The positions differed very little from those given by M. D'Arrest, in No. 880 of the *Astronomische Nachrichten*."

On the Orbit of the Eighth Satellite of Saturn.
By Warren De La Rue, Esq.

At one of the meetings of the Society held last year Mr. De La Rue exhibited a diagram of the apparent orbit of the eighth satellite of *Saturn* for the 16th of November, 1852, founded on his own micrometrical measurements, and those of Mr. Lassell at Malta. By a graphic process he obtained the following rough approximation to the elements of the true orbit of the satellite:—

Mean longitude on orbit, Nov. 16, 1852 ...	265°	
Semi-major axis at mean distance	514″·7	
Eccentricity	0·025	
Longitude of Perisaturnum	130°	M. Equinox, 1852·0
Longitude of ascending node	141° 20′	
Inclination to the ecliptic	18° 30′	
Sidereal revolution	$79^d\,9^h\,13^m\,12^s$	

Extract of a Letter from W. C. Bond, Esq., to the Editor.

"Perhaps I ought to have informed you earlier, that on the 28th of November I received a letter from Mr. Robt. Van Arsdale, of Newark, New Jersey, in which he says, under date of November 25th, as follows:—

"'I noticed a comet last evening in the constellation *Cassiopeiæ:* it is small, round, and bright, in a refractor of $6\frac{1}{8}$ inches aperture. Its approximate place, Nov. 25, at $6^h\ 50^m$ Newark mean solar time, was, right ascension, $2^n\ 7^m$; north declination, 60° 12′.'

"This comet was subsequently observed several times by Mr. Van Arsdale and by ourselves; and is no doubt the same seen by M. Klinkerfues on the 2d of December. Inclosed you will find our observations on this comet. Of late we have been too busily engaged in other matters, particularly in reducing zones of small stars, which we had observed by the electric method, to give much of our attention to comets.

Observations on Van Arsdale's Comet, made at the Observatory of Harvard College.

	Camb. M.S.T.	Δα, Comet − ✱	Δδ, Comet − ✱	
	h m s	m s	′ ″	
1853, Dec. 14	12 52 28·4	−1 24·24	−7 8·1	*a*
15	6 51 23·9	+1 16·74	+6 14·3	*b*
24	7 32 24·2	+0 16·63	+2 30·7	*c*
27	7 0 46·8	+0 2·15	+5 0·5	*d*
1854, Jan. 2	7 8 58·8	+0 42·50	+6 13·6	*e*

Mean Places of the Stars of Comparison referred to the Mean Equinox of the beginning of the years 1853 and 1854.

Star	α 1853·0	δ 1853·0	Authority.
	h m s	h m s	
a	1 15 17·01	+26 56 48·1	B.A.C. 409
b	1 12 10	35 59	Approximate 9th mag.
c	1 6 40	26 36	— —
d	1 5 46·42	23 48 17·7	B.A.C. 365
e	1 4 33·35	+18 57 48·0	10th mag. comp. with B.A.C. 336

"*Harvard College Observatory, Cambridge, Feb.* 16, 1854."

Extract of a Letter from M. Otto Struve to the Astronomer Royal, dated January 17, 1854.

"You will see by the enclosed paper that our Academy has resolved to propose the theory of Biela's Comet as a prize problem. Be pleased to insert our programme in the *Monthly Notices.* On that occasion it might be mentioned that all stars used formerly for comparison with the comet, and the positions of which appear not to be sufficiently ascertained, will be reobserved during the present

year with our meridian circle. A part of the work is already done."

The following is the programme alluded to by M. Otto Struve:—

Programme of a Prize for Astronomy proposed by the Imperial Academy of Sciences of St. Petersburg, at their Sitting on the 29th of March, 1853.

The disruption of the comet of Biela into two bodies apparently separated by an empty space is a unique event in the annals of astronomy. This catastrophe, which occurred in 1846, almost under the eyes of astronomers, has been followed by extraordinary changes in the aspect and brightness of the two heads. Analogous changes were again exhibited on the occasion of the return of the comet in 1852, notwithstanding the considerable augmentation of the mutual distance of the two heads. They indicate, according to all appearance, the continued existence of a mutual action of a very remarkable character. All these circumstances concur to render the comet of Biela an object of the very highest scientific interest. Further, it is to be remarked that, on the occasion of the last apparition of the comet in 1852, the observed positions have differed enormously from the ephemeris calculated beforehand by Sig. Santini, and that it is not yet decided whether the differences between theory and observation ought to be attributed solely to the imperfect nature of the calculations, or whether they have been produced by forces which, at the time of the subdivision of the comet, had effected violent alterations in the orbit. Consequently, a vigorous investigation of the orbit of the comet has appeared to the Imperial Academy of Sciences to be worthy of being proposed to the competition of astronomers and geometers, as the subject of an extraordinary prize. Considering that it is impossible, under present circumstances, to foresee all the consequences to which the researches will lead, the Academy does not think that it would be desirable to restrict too rigorously the problem proposed for solution.

The programme is accordingly comprised in the following points:—

1. The Academy demands a rigorous investigation of the elements of the orbit described by the centre of gravity of the comet of Biela; which must be founded on a minute discussion of all the observations obtained during the six apparitions observed between 1772 and 1852, respect being had to the sensible perturbations produced by the planets.

2. In case it may not be possible to represent in a satisfactory manner all the observations by means of a single orbit, it will be necessary to divide the investigation into two parts, one of which will embrace the observations from the earliest period down to the epoch of the separation of the two heads; the other will include all the observations made from that epoch down to the present time.

3. The investigation should be especially directed to the mutual relations of the two heads, in order to determine not only the posi-

tion of the centre of gravity of the two heads, but also, if it be possible, the laws according to which the alterations of their relative positions are effected.

4. The memoir for competition ought to be accompanied by an ephemeris, calculated beforehand for the next apparition of the comet in 1859.

Considering the long and troublesome calculations which the complete solution of this problem will demand, the Academy fixes the 1st of August, 1857, as the term for presenting the memoirs destined for competition. The adjudication of the prize will take place at the public sitting of the same year.

The memoirs for competition may be written in Russian, Latin, French, German, or English. They are to be addressed anonymously, "*To the Imperial Academy of Sciences of St. Petersburg*," but furnished with a motto. A sealed packet annexed bearing the same motto as the memoir will contain the name and address of the author. The memoir crowned will be published by the Academy, and the author will have fifty copies placed at his disposal. The packets of the unsuccessful memoirs will be burned, and the memoirs will be placed at the disposal of the authors.

The prize is fixed at 300 ducats of Holland.

There will be besides an *accessit* of 150 ducats of Holland.

Mr. Hind, the Foreign Secretary of the Society, has received a letter from M. C. Rümker, in which he begs the Society to accept his warmest thanks for the honour they have conferred on him in awarding him the gold medal of the Society. Dr. Lee has also received a letter from M. Rümker, in which the writer states that the Burgomaster and their High Worships the Senators and Aldermen of Hamburg, in consequence of the honour which the Royal Astronomical Society has thus conferred on the Director of their Observatory, have decreed to repair and enlarge the latter, and to mount it with a better revolving dome. They have also held out the hope of furnishing it with a larger equatoreal.

Mr. Guthrie, a gentleman residing near Bervie, N. B., wishes to call the attention of astronomers to a phenomenon which he states to have observed in the planet *Venus* a few years ago. On the occasion of the approach of the planet to its inferior conjunction, and when the crescent was very slender, Mr. Guthrie, while engaged in examining it with a Newtonian reflector of 5 inches aperture and a magnifying power of 144, was unexpectedly surprised by observing an annular fringe of light surrounding the dark side of the disk, and completing the circle which was partially formed by the outer margin of the crescent. The same appearance was observed when the planet was viewed with a Gregorian reflector of $3\frac{1}{2}$ inches aperture, magnifying 68 times. In order to assure himself beyond doubt of the reality

of the phenomenon, Mr. Guthrie directed some of his friends to examine the planet through his instruments, but without communicating to them a knowledge of the object he had in view; whereupon each of them remarked that he observed the same appearance. This luminous continuation of the cusps of the planet was observed on several consecutive nights, the atmosphere having been very favourable for observation. It increased in visibility as the crescent waned. The breadth was considerable: neither the interior nor the exterior side of it was sharply defined.

Mr. Guthrie states that the instruments with which the planet was examined were both of excellent quality. The fringe was better defined in the larger instrument than in the smaller; being of a nebulous appearance, it was more distinctly visible in the smaller than in the larger instrument.

Mr. Guthrie ascribes the luminous appearance above mentioned to the existence of an atmosphere about *Venus*. He was prevented by the unfavourable state of the weather from verifying the existence of the phenomenon on the occasion of the late inferior conjunction of the planet. It is well known that Schroëter observed a similar continuation of the cusps of the planet, although not so extensive as to form with the crescent a complete circle of light.

Astronomical Observations made at the Observatory of Cambridge. By the Rev. James Challis, M.A., Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge, and late Fellow of Trinity College. Vol. xvii. for the years 1846–7–8. 4to. Cambridge, 1854.

This volume contains the meridian observations with the transit and mural circle, and the occultations of stars by the moon, for the years 1846–7–8. The observations of comets and planets with the Northumberland equatoreal have been reserved for a separate publication.

The meridian observations of 1846 are confined to stars, with the exception of observations of the planet *Neptune* in the last quarter. In 1847 an effort was made to resume meridian observations of bodies of the solar system, and, accordingly, in that year the Sun, the Moon, *Jupiter*, *Saturn*, and *Uranus*, and the new planets, *Neptune*, *Flora*, *Iris*, and *Astræa*, were observed. But the pressure of the work with the Northumberland equatoreal in observing planets and comets rendered it necessary, after February 1848, to restrict the meridian observations of moving bodies to the newly-discovered planets. Of these *Flora*, *Metis*, *Hebe*, *Astræa*, and *Neptune*, were observed in 1848.

A large number of the stars observed in the three years were used for comparison in equatoreal observations. The rest are double stars in Struve's catalogues, moon-culminating stars, occultation-stars, stars whose places are imperfectly determined in the British Association Catalogue, and the stars observed for instrumental corrections.

*Determination of the Difference of Longitude between Frankfort-on-the Maine and Berlin by Means of Galvanic Signals.** By M. Encke.

The two extreme stations were Paul's Tower, Frankfort, and the new Observatory, Berlin. M. Encke and Dr. Brünnow observed at the latter station, and Dr. Lorey at the former. The telegraph apparatus used is Morse's. It was agreed that Dr. Lorey should decide in every case upon the day for making the experiments, in order that he might be enabled to determine the time with accuracy. He was then to announce by a signal that the experiments were about to commence, and after this note of preparation he was to make a series of signals during the next ten minutes, it being arranged that he was to make a new signal about the beginning of each successive minute. M. Encke observed the corresponding time at the Telegraphic Office, Berlin, upon a chronometer by Tiede, which was regulated according to mean time; Dr. Brünnow made similar observations with a chronometer by Tiede regulated to sidereal time. The ten signals being observed, Dr. Brünnow gave a signal from Berlin to announce that a new set of experiments was about to commence, and this was followed by ten successive signals as before. The time was observed in this case by Dr. Lorey at Frankfort, and by M. Encke at Berlin. Since the time of each approaching signal was known within a few seconds, the observer could wait for its actual arrival with unremitting attention.† In this way all went on quickly and without any disturbance. Only on the second day was the last signal imperfectly observed. M. Encke then gives the details of the observations. The following are the final results for the longitude of Frankfort west of Berlin :—

Signals from Frankfort.

	m	s		m	s	
Aug. 12	18	51·99	E	18	51·72	B
28		51·71			51·85	
	18	51·75	E	18	51·79	B

Mean $18^m\ 51^s{\cdot}77$

Signals from Berlin.

	m	s		m	s	
Aug. 12	18	51·57	E	18	51·93	B
28		51·91			52·13	
	18	51·74	E	18	52·03	B

Mean $18^m\ 51^s{\cdot}89$

or, on the whole, a mean difference of longitude amounting to $18^m\ 51^s{\cdot}83$. The difference of the two results cannot arise from the circumstance that the transmission of the signal is not instantaneous, since, during the interval of transmission, the Frankfort signals ought to have arrived too late at Berlin, in which case the

* *Ast. Nach.* No. 889. † Mit gespannter aufmerksamkeit.

difference of longitude should have turned out too great, while again the Berlin signals, by arriving too late at Frankfort, should have indicated the difference of longitude to be too small. In reality, however, the Berlin signals made the longitude west *greater* than its true value. These two experiments, consequently, indicate that, as regards the means of observation herein employed, the velocity of the electric current is insensible for the distance between Frankfort and Berlin, a distance which, taking into consideration the circuitous route of the telegraph, certainly exceeds 60 German miles.

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